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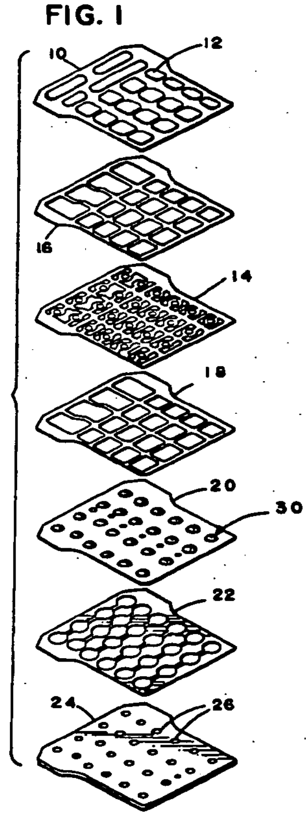
(54) Backlit tactile keyboard with improved tactile and electrical characteristics.

(57) Disclosed is a keypad for use with compact and portable cellular telephone systems in which each key is backlit. A partially translucent overlay layer (10) of flexible material includes a raised key (12). Under the key (12), in a preferred embodiment, is an actuation layer (14), which, during operation, is depressed downward by the key (12). Below the actuation layer (14), is a tactile feedback layer (20) including a dome (30) for each key (12), in which, after being depressed to a predetermined degree, the dome (30) inverts causing a conductor (44) located below the dome (30) to short conductive traces (28) on a substrate (24) upon which the keypad is mounted. In a preferred embodiment, the keys are backlit by a light source (40) extending through the substrate (24) upon which the keypad is mounted. The tactile feedback layer includes a structure for reducing pressure on the light source when the tactile layer (20) is in the inverted condition, resulting in a thinner keypad with a brighter backlit key and a longer lift light source.

FIG. I



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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to switch keypads and, more particularly, to an improved rubber keypad useful for cellular portable telephones.

2. Discussion of Prior Art

With the proliferation of portable cellular telephones, there has been an increasing need for telephone keypads which have the individual keys illuminated in some fashion to aid in their operation. An additional necessity of such a keypad is a means for providing a tactile feedback which is an indication that the particular key has been actuated.

In the past, relatively high-profile keypads incorporating plunger-type actuating keys have been utilized to permit back illumination as well as good tactile feedback. Generally, such high-profile keys utilize a carbon conductor or a metallic popple dome rendering back illumination difficult. Such problems have been solved in part by using a separate light pipe (see U.S. Patent No. 4,124,879) or a thick rubber pad itself as a light pipe (see U.S. Patent No. 4,636,593) for distribution of required illumination to the keys of the keypad. However, because the thickness of such high-profile keypads requires a substantial increase in the overall dimensions of the cellular portable telephone system, it is desirable to provide a low-profile, rubber keypad with a similar degree of illuminability.

U.S. Patent 4,916,262 is an example of such a low profile, rubber keypad which permits illumination to pass through a diffuser plate and through various translucent layers of the keypad. However, such a construction suffers from poor simultaneity of tactile feedback and electrical contact. Further, the illumination levels required in order to provide acceptable illumination of the key itself requires an unacceptable power drain during operation.

A further problem with U.S. Patent 4,916,262 is the existence of a separate shorting layer requiring a further adhesive layer in order to bond the shorting layer in the appropriate interrelationship. The shorting layer, and its necessary adhesive layer, add to the thickness of what is desired to be a low-profile keypad.

It has been proposed to utilize light emitting diodes which provide the desired level of illumination with an acceptable power drain. In order to utilize the light generated by the light emitting diode (LED), it is generally felt necessary to mount the LED directly under the key of the keypad. However, in this instance, the height of the light emitting diode above the printed circuit board upon which it is mounted serves to interfere with operation of the conventional tactile feedback dome unless the dome is spaced a substantial vertical distance from the light emitting diode. Accordingly, the use of LED illuminated rubber keypads has in the past precluded the manufacturer of a low-profile keypad.

SUMMARY OF THE INVENTION

In view of the above and other disadvantages of prior art keypads, it is an object of the present invention to provide an LED equipped keypad which retains a relatively low profile.

It is a further object of the present invention to eliminate the need for a separate shorting layer and its related adhesive layer in the construction of a low-profile keypad.

It is a still further object of the present invention to develop a backlighted tactile key where the lighting device is raised above the top surface of the mounting board for the keypad without adversely affecting the lighting device when activating the key.

It is an additional object of the present invention to improve simultaneity of electrical contact with tactile feedback in a keypad switch.

The above and other objects are achieved in accordance with the present invention by providing a double dome in the tactile or popple element, such that when it is compressed beyond its maximum resistance, it snaps or pops into a depressed condition which will be maintained as long as key pressure is maintained. When the larger dome is in the inverted condition, the smaller dome is not inverted. This can provide a circular ridge at the junction which may serve to concentrate the closure forces between the conductive coating on the dome and the circuit conductors on the substrate.

The double or second and smaller dome is not compressed and serves to provide a clearance between the center portion of the tactile dome and the light emitting diode which may extend above the printed circuit board mount. This as a minimum, permits a reduction in pressure on the LED which would otherwise be applied during actuation of the keypad, while at the same time, permitting the keypad to retain the low profile characteristics.

In a further preferred embodiment, electrodes are conventionally mounted on the printed circuit board around an aperture through which the light emitting diode extends and the shorting electrodes comprise conductors disposed on the under surface of the tactile dome. Thus, during actuation, the tactile dome itself actually contacts and shorts the PCB circuits. In variations upon this embodiment, a conductor on a membrane under the dome is connected to one circuit element and another conduc-

tor on the printed circuit board surface, and the two are electrically connected when the dome is inverted during key operation. Preferred embodiments include a low resistance actuator layer, and a stiffening ring on the membrane to further improve reliability of operation.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects of the present invention will be better understood by reference to the following drawings wherein:

FIGURE 1 is an exploded perspective view of one embodiment of the present invention;
FIGURE 2 is a plan view of a portion of an actuator layer;
FIGURE 3a and 3b are top and side views of one typical tactile dome design;
FIGURE 4 is a side cross-sectional view of one embodiment of the present invention;
FIGURE 5 is a side cross-sectional view of the embodiment disclosed in Figure 4 in an actuated condition;
FIGURE 6 is a side cross-sectional view of a further embodiment of the present invention;
FIGURE 7 is a side cross-sectional view of a still further embodiment of the present invention;
FIGURE 8 is a side cross-sectional view of an additional embodiment of the present invention;
FIGURE 9 is a top view of a typical conductive trace pattern in one embodiment of the present invention;
FIGURE 10 is a plan view of a further embodiment of a portion of the actuator layer; and
FIGURE 11 is a side cross-sectional view of a still further embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Similar reference numerals will be used in the respective Figures for similar parts. With reference to Figure 1, there is shown a number of elements making up a backlit keypad in accordance with one embodiment of the present invention. A rubber keypad overlay 10 is provided which has raised keys 12. The rubber keypad overlay 10 is bonded to actuator layer 14 by use of graphic adhesive layer 16. The actuator layer 14 is bonded to and over actuator spacer 18 which is a preferred embodiment is a thin layer of adhesive. Similarly, the actuator spacer is bonded to the conductive dome membrane 20 which in turn is also mounted to spacer 22 by a similar adhesive layer (not shown). The spacer also utilizes another adhesive layer (not shown) to bond the entire assembly to the printed circuit board 24 which can of either rigid or flexible design.

The printed circuit board 24 includes a plurality of apertures 26 through which a light emitting diode (not shown) can extend to provide illumination.

In preferred embodiments, the rubber keypad overlay 10 is comprised of a flexible silicon rubber overlay with a flat bottom surface and raised keys 12 on an upper surface. In order to reduce the thickness of the overall keypad, a flat, ridged or embossed polyester sheet could also be used in place of the rubber layer. In one embodiment, the printed circuit board 24 comprises a 0.062 inch G-10 rigid board or Kapton-based flexible circuit available from any electrical supplier. In such an embodiment, the conductive traces 28 are laminated conductors, which form a part of the board, with insulating areas being etched away. A further embodiment would be to utilize a polyester layer with printed silver conductive traces thereon as interdigitated conductors around the LED holes.

Reference may be had to Figure 9 which illustrates the interdigitated electrode connections around each of the LED holes. Of course, each of the interdigitated patterns would be connected to a different circuit element so as to provide an identifiable signal with respect to each key which is depressed. The silver trace patterns 28 associated with a particular dome comprises in each instance two separate conductors whose interconnection is made by a bridging conductor element carried by the conductive dome membrane 20.

The conductive dome 30 in a preferred embodiment is shown in Figures 3a and 3b is comprised of .005 inch thick Dupont Mylar (polyester or PET) film which in a preferred embodiment, comprises a large radius dome 32 topped by a small radius dome 34.

In a preferred embodiment, the large radius dome has a diameter at dimension A which is preferably within the range of 0.200 to 0.350 inches (one preferred embodiment is 0.250 inches) and the small radius dome 34 has a diameter at dimension B preferably within the range of 0.060 to 0.125 inches in diameter (one preferred embodiment is 0.062 inches). The vertical height of the outer dome in one embodiment is 0.017 inches and the vertical height of the small radius dome is 0.024 inches (total height above the lower surface of the 0.005 inch thick polyester sheet). The thickness of the sheet can vary depending upon the invert pressure desired, but in a preferred embodiment is between .004 and .007 inches thick (0.005 in one preferred embodiment).

Obviously, depending upon the tactile characteristics required and the force necessary to cause the large radius dome to "invert", different materials, diameters and height to diameter ratios will be used. It is noted that since the thickness of the polyester sheet generally remains the same for both the large and small radius domes, because of

its larger dimensions, the large radius dome will be easier to deform than the small radius dome. Consequently, upon actuation of a key, the large radius dome will collapse providing the tactile feedback well before the pressure level is reached necessary to begin to cause the small radius dome to collapse.

The actuator spacer 18 in a preferred embodiment is a 0.002 inch layer adhesive 3M adhesive #3M 467. However, if a thicker spacer is desired, a sandwich of a 0.002 inch layer of Dupont Mylar (Polyester Teraphthalate or PET) with a 0.002 inch layer of 3M adhesive #3M 467 on each side will provide a suitable spacer 0.006 inches thick.

The actuator layer itself in a preferred embodiment comprises a 0.005 inch Mylar (PET) layer with a cutout pattern which is shown in more detail in Figure 2. As will be more clearly seen later with reference to Figures 6 and 7, the actuator layer 14 in effect is a suspended ring having an outer diameter at 36 which in a preferred embodiment is within the range of 0.150 to 0.250 inches and an inner diameter of 0.060 to 0.125 inches. It is noted that in a preferred embodiment the inner diameter of the ring 38 is approximately the same size as the diameter of the small radius dome 34 and the interrelationship therebetween will be seen with reference to Figures 6 and 7. Furthermore, if it is desirable to stiffen the actuator even more, the inner or outer edges of the ring (or both) can be embossed with a ring 54 as shown on the dome in Figure 7.

A further embodiment of the actuator layer is shown in Figure 10 in which only a single tab 60 connects the ring 62 to the periphery of the actuator layer. Inner aperture 64 is optional but can be advantageously used in the event clearance with the double dome is needed. The use of a single tab 60 decreases the resistance of the actuator layer to deflection during operation of the keypad.

It is noted that the graphic adhesive layer 16 in a preferred embodiment comprises 0.005 inches of silicon adhesive available from 3M Corporation, adhesive #3M 9675 used with a primer to promote adhesion. However, an alternative embodiment would be a 0.002 inch thick layer of #3M 9732 adhesive, with or without a primer. The other adhesive layers (not shown) in preferred embodiments would be 0.002 inch layers of 3M adhesive #3M 467. While adhesives have been shown as a means for maintaining relative positions of the layers, different types of adhesives could be used which are compatible with the materials chosen and indeed materials other than adhesives could be used to maintain the position of the layers (such as thermal bonding or locating pins which are subsequently bonded between the stack of layers).

While not absolutely critical for operation, one preferred embodiment of applicant's invention utilizes actuator layer 24 and a cross-sectional view of this embodiment is illustrated in Figure 6. However, an embodiment not utilizing the actuator layer is shown in Figure 4 in the unactuated condition and in Figure 5, in the actuated condition. With reference to Figures 4 and 5, the light emitting diode 40 protrudes through aperture 26 and may project above printed circuit board 24 by as much as 0.12 inches or more in order to provide the desired lighting of the raised key 12 on rubber keypad overlay 10.

The polyester adhesive layers 42 are shown and serve to mount the dome spacer layer 22, the conductive dome membrane 20 and the actuator spacer 18 to the printed circuit board 24. The graphic adhesive layer 16 may be a different type of adhesive layer suitable for mounting the rubber keypad overlay 10 on the stacked assembly. The lower trace patterns 28 are illustrated on the printed circuit board surrounding LED 40. Conductive material 44 is located on the underside of the large radius dome 32 and may be applied by the vapor deposition, printing or other conventional methods for providing a conductive layer on a polyester dome. In a preferred embodiment, a conductive silver coating is applied to the under surface of the dome.

The operation of the Figure 4 device is illustrated in Figure 5 whereupon raised key 12 has been depressed. As the key is depressed, it can be seen that it in turn depresses the small radius dome 34 providing an increasing compression force to the large radius diameter dome 32. A force level will be reached at which the large radius dome 32 will invert to the conditions shown in Figure 5 allowing conductive material 44 to "short" or interconnect the interdigitated lower trace patterns 28. This process of inverting or "snapping" provides a tactile indication to the user that will coincide with the effective actuation of the switch. The inverting of the dome also provides an actuation force for closure of the electrical switch formed between the trace patterns 28 and the conductive material 44. Where a separate shorting layer is utilized, it is sometimes more difficult to obtain simultaneity of electrical contact with the inverting action of the large radius dome. However, where the conductive dome approach is used and a conductive layer 44 is applied to the lower surface of the larger dome there is a greater probability of electrical shorting between the lower trace patterns 28.

It will be seen in the Figure 4 and Figure 5 embodiment that the pressure of the raised key 12 is transferred directly to the small radius dome 34 which then depresses the large radius dome 32

until it "inverts" to cause electrical interconnection of the electrical trace patterns 28. It will be seen, however, that even in its collapsed state, the small radius dome 34 maintains a clearance with LED 40 (in a preferred embodiment) or at least contacts LED 40 with less force than would be the case if only a single large radius dome were utilized. This feature permits LED 40 to be mounted at a sufficient distance above the printed circuit board 24 to provide good illumination of the raised key 12 without requiring an exceptionally thick keypad assembly. It will be seen that based upon the above discussion, varying thicknesses of the layers illustrated in Figures 4 and 5 can be utilized to accommodate the desired extension of LED 40 above the printed circuit board to minimize the pressure of the inverted dome on the LED itself. Different apertures with respect to these spacers will also provide different operational characteristics depending again upon the thickness of the materials used, the force necessary to provide "inverting", etc.

In Figure 6, a keypad similar to that illustrated in Figure 1 is shown including the actuator layer 14. The actuator layer in a preferred embodiment would be of the form illustrated in Figure 2 with the inner diameter of the ring 38 being seen as the aperture in the actuator layer. The Figure 6 embodiment illustrates the use of the top layer of adhesive 42 as the sole actuator spacer. During operation of the Figure 6 embodiment, it can be seen that the raised key 12 will deflect the actuator layer 14 downward such that either first contact will be between the actuator layer 14 and the large radius dome 32 around the inner edge of inner diameter 38 or even if there is initial contact between the small radius dome 34 and the underside of raised key 12, this will be minimal contact compared to the contact between the actuator layer and the large radius dome. This will result in a more positive actuation of the inverting characteristic of the large radius dome 32 and a better "tactile" feel to the switch.

Figure 6 also illustrates a circular dimpling 50 which when coated with a conductive coating appears to concentrate the actuation contact force between conductive material 44 and the trace patterns 28 during inversion of the dome resulting in a more positive electrical contact. Figure 6 also illustrates an embodiment in which the light source 40 does not extend above the lower substrate 24 which is also applicable to the other illustrated embodiments.

In the Figure 4 and 5 embodiment, due to the silicon rubber nature of the undersurface of raised key 12, it is deformed during actuation, at least to a certain degree, by the small radius dome 34 prior to "inverting" of the large radius dome. This deformation would require a substantially longer key stroke and perhaps a less definite feel to the switch actuation. This problem is overcome with the use of an actuation layer. The drawback of the Figure 6 and Figure 7 embodiment, of course, is that it requires one additional polyester layer along with the necessary adhesive to mount that layer and thus comprises a slightly thicker keypad sandwich. The use of an actuator layer 14 as in Figure 6, allows direct transmission of the key depression force to the large radius dome 32 without the necessity to contact small radius dome 34.

In some embodiments, as shown in Figure 7, it will be unnecessary to utilize small radius dome 34 and the large radius dome 32 can conveniently have aperture 46 located therein. The operation is similar to the operation of the embodiments shown in Figures 4 and 6 except that there is no danger of the small radius dome striking or exerting any force on the upper portion of LED 40. In the device of Figure 7, an alternate embodiment would be the utilization of a metal dome 52 which permits sufficient light from LED 40 to illuminate raised key 12 through aperture 46 and, due to its conductivity, eliminates the need for separate conductive material 44 to short lower trace patterns 28. In embodiments, such as Figure 7, in which a large radius dome is utilized with a centrally located aperture, it may be necessary to provide an embossed ring 54 around aperture 46 comprising in effect a strengthening ridge, in order to stiffen the edge of the aperture to aid in the "inverting" action of the dome. Such an embossed ring might be of greater necessity in a single dome made of polyester plastic with an aperture.

One benefit of the present invention is the utilization of a conductive dome to eliminate the need for a separate shorting layer as disclosed in U.S. Patent 4,916,262. However, where it is desirable to utilize an LED in order to illuminate the raised key in a device such as U.S. Patent 4,916,262, a conductive shorting layer could advantageously be used in combination with a tactile dome in a fashion similar to that illustrated in Figure 8. Instead of spacer layer 22, a shorting layer 48 would be provided which could either be conductive metal or be a non-conductive substrate as illustrated with conductive material 44 located thereon.

The operation of the Figure 8 embodiment is similar to the other embodiments in that when the large radius dome "inverts", it forces the conductive portion of the shorting layer to contact the lower trace patterns closing the switch. The double dome configuration again can be advantageously utilized to provide protection to the LED, while at the same time maintaining a very low profile and yet well illuminated key. Where a metallic dome is

desirable for tactile feedback characteristics, the ring shaped actuator layer can be advantageously utilized to improve the pressure distribution from the key to the dome. Further, contact between the conductive material 44 and the trace patterns 28 can be improved by conductive ridge 56 which improves conductivity by concentrating the contact force.

A further embodiment of the present invention is illustrated in Figure 11. Shorting layer 48 has a preferably non-conductive material in the form of ring 70 printed on the upper surface to stiffen the shorting layer to improve the simultaneity of electrical closure and tactile response during operation of the keypad. Such a stiffening ring 70 can be in place of or in conjunction with the ridge 56 and can be comprised of any material which can be adhered to the surface of the shorting layer 48. In a preferred embodiment, an ultra-violet curable mixture of 85% Acheson "ML 25094" clear dielectric (available from Acheson Industries, Inc., Acheson Colloids Company, P.O.Box 288, Port Huron, Michigan 48060) and 15% W.R.Grace "Flexcoat SW" clear dielectric (available from W.R. Grace & Company, 5210 Phillip Lee Drive, SW, Atlanta, Georgia 30336) is screen printed onto the shorting layer and cured.

When a shorting layer 48 is used, there are some disadvantages in using the shorting layer only to bridge pairs of conductors on the printed circuit board as in the embodiment shown in Figure 8. An improved further embodiment is shown in Figure 11 in which, for one keypad, one conductor 72 is located on the printed circuit board 24 and the other conductor 74 is located on the shorting layer 48. When the raised key 12 is depressed and thereby depresses the actuator, the dome inverts forcing conductors 70 and 72 into electrical contact.

Because the conductive material 44 in Figure 8 served only to short a pair of conductors or lower trace patterns 28 already located on the PCB-(shown in Figure 8 without PCB circuit interconnections), no interconnections between the shorting layer and the PCB were necessary. However, in the Figure 11 embodiment, it will be necessary to interconnect the conductor 74 with the appropriate PCB circuit (not shown). This is accomplished through conductive extension 76 which extends to aperture 78 in the lower adhesive layer 42. A conductive epoxy 80 is utilized to electrically interconnect the extension 76 with the appropriate electrical circuit component on the PCB (not shown). Any suitable conductive material could be used although in a preferred embodiment epoxy sold by Epoxy Technology Inc., 14 Fortune Drive, Billerica, Massachusetts 01821, under the trade name EPO-TEK H20E® is advantageously used.

The use of one conductor on the shorting layer 48 and the other on the PCB 24 permits more consistant switch operation with respect to when, during the depression stroke of the raised key 12, the conductors 72 and 74 make contact. It is also to be noted that the actuator layer shown is of the type illustrated in Figure 10.

In view of the above, and with respect to the level of skill of those having ordinary skill in the keypad switch art, many modifications and embodiments of the present invention will be obvious. As noted earlier, different materials can be used for the various layers and as disclosed in some embodiments, certain layers can be eliminated. Different adhesives or other methods of bonding the layers to an adjacent layer or maintaining the relative position of the elements in the keypad "sandwich" can be utilized. For example, different sources of illumination can be provided other than light emitting diodes, such an incandescent lights, electrode luminescent light systems, etc. Further, it is unnecessary to have the light source located directly under the key and indeed it could be located off to one side. It would be desirable to shift the location of the small radius domes so as to coincident with the light emitting diode, thereby providing the benefits of the direct alignment, although some benefits of the present invention could be realized with some small misalignment between the light source and the conductive dome.

Therefore, the above discussed preferred embodiments by way of example only and additional modifications and variations thereof will become obvious to those of ordinary skill in the art in view of the present specification. Therefore, this invention is limited only by the claims appended hereto.

Claims

1. A keypad for mounting over a substrate and providing at least one key, said at least one key being backlit by at least one light source, said keypad comprising in combination:

   an at least partially translucent overlay layer means having a top surface with at least a portion of said top surface comprising at least one key;

   tactile layer means, located under said overlay layer means and having at least one collapsible resilient dome substantially aligned with a corresponding said at least one key, for providing a tactile feedback and an actuation force when said at least one key is depressed a predetermined amount and said at least one resilient dome inverts, said resilient dome including at least a light transmissive area, said tactile layer means including a means for stiffening said dome around said light transmissive

area;

circuitry layer means, located under said tactile layer means and on said substrate, having at least one conductor located thereon, said at least one conductor being substantially aligned with a corresponding dome of said tactile layer;

shorting layer means, with at least one conductive area located between said at least one resilient dome of said tactile layer means and a corresponding said at least one conductor of said circuitry layer means and responsive to said tactile layer means, for electrically contacting a corresponding said at least one conductor with said at least one conductive area when said key is depressed and said at least one resilient dome inverts, said shorting layer means including means for passing light from said at least one light source to said at least one key; and

means for maintaining the relative positions of said overlay layer means, said tactile layer means, said circuitry layer means, and said shorting means.

2. A keypad according to claim 1, wherein each of said at least one resilient domes include a smaller dome thereon, said smaller dome comprising a means for improving force distribution when said at least one resilient dome inverts and for permitting passage of light from said at least one light source to said at least one key,

3. A keypad according to claims 1 and 2, further including an actuation layer means, located between said overlay layer and said tactile layer means, for concentrating force from said at least one key at at least one point when said at least one key is depressed during operation, said actuation means including means for permitting passage of light from said at least one light source to said at least one key;

4. A keypad according to any of claims 1, 2 and 3, wherein said resilient dome comprises a metal collapsible resilient dome with said metal dome including at least a conductive area thereunder and said resilient dome light transmissive area comprises an aperture in said dome.

5. A keypad according to any of claims 1 through 4, further including means for electrically interconnecting said at least one conductive area of said shorting layer means with said circuitry layer means.

6. A keypad according to any of claims 1 through 4, wherein said circuitry layer means includes at least one conductor pair and said shorting layer means bridges said conductor pair during key actuation.

7. A keypad according to any of claims 3 through 6, wherein said actuator layer means includes a plurality of actuating strips, each actuating strip being substantially aligned with a corresponding key, each actuating strip including a ring, said ring located substantially under said key.

8. A keypad according to Claim 7, wherein said actuator layer means includes a remainder portion, a ring portion and a plurality of tabs connecting each ring to said remainder portion.

9. A keypad according to Claim 7, wherein said actuator layer means includes a remainder portion, a ring portion and a single tab connecting each ring to said remainder portion.

10. A keypad according to any of claims 5 through 9, wherein said shorting layer means includes a conductive ridge means for improving electrical contact between said at least one conductor and said at least one conductive area.

11. A keypad for mounting over a substrate and providing at least one key, said at least one key being backlit by at least one light source, said keypad comprising in combination:

an at least partially translucent overlay layer means having a top surface with at least a portion of said top surface comprising at least one key;

an actuation layer means, located under said overlay layer, for concentrating force from said at least one key at at least one point when said at least one key is depressed during operation, said actuation means including means for permitting passage of light from said at least one light source to said at least one key;

a tactile layer means, located under said actuation layer means and having at least one collapsible resilient dome, said at least one dome being substantially aligned with a corresponding said at least one point of said actuation layer and said key, for providing a tactile feedback and an actuation force when said at least one key is depressed a predetermined amount and said at least one resilient dome inverts, said at least one resilient dome including a smaller dome thereon, said smaller dome comprising a means for improving force distribution when said at least one resilient

dome inverts and for permitting passage of light from said at least one light source to said at least one key;

a circuitry layer means, located under said tactile layer means and on said substrate, having at least one conductor located thereon, said at least one conductor being substantially aligned with a corresponding dome of said tactile layer;

shorting layer means, with at least one conductive area located between a corresponding point of said tactile layer means and a corresponding said at least one conductor of said circuitry layer means and responsive to said tactile layer means, for electrically interconnecting a corresponding said at least one conductor with said at least one conductive area when said key is depressed and said at least one resilient dome inverts, said shorting layer means including means for passing light from said at least one light source to said at least one key;

means for electrically interconnecting said at least one conductive area of said resilient dome with said circuitry layer means; and

means for maintaining the relative positions of said overlay layer means, said actuation layer means, said tactile layer means, said circuitry layer means and said shorting layer means.

12. A keypad according to any one of claims 5 and 7 through 11, wherein said shorting layer means comprises:

a planar layer, at least partially between said tactile layer means and said circuitry layer means, and said conductive area including a portion at least partially in registration with said at least one conductor on said substrate, said conductive area further including a conductive extension at least partially extending away from registration with said at least one conductor; and

said means for electrically interconnecting comprising a means defining an opening between at least a portion of said conductive extension and said circuitry layer means, and means, at least partially disposed in said opening, for electrically interconnecting said conductive extension and said circuitry layer means.

13. A keypad according to Claim 11 or 12, wherein said actuator layer means includes a plurality of actuating strips, each actuating strip being substantially aligned with a corresponding key, each actuating strip including a ring, said ring located substantially under said key.

14. A keypad according to Claim 13, wherein said actuator layer means includes a remainder portion, a ring portion and a single tab connecting each ring to said remainder portion.

15. A keypad according to any one of claims 1-14, wherein said at least one key comprises a plurality of keys, each of said keys comprising a raised key portion on said overlay layer means.

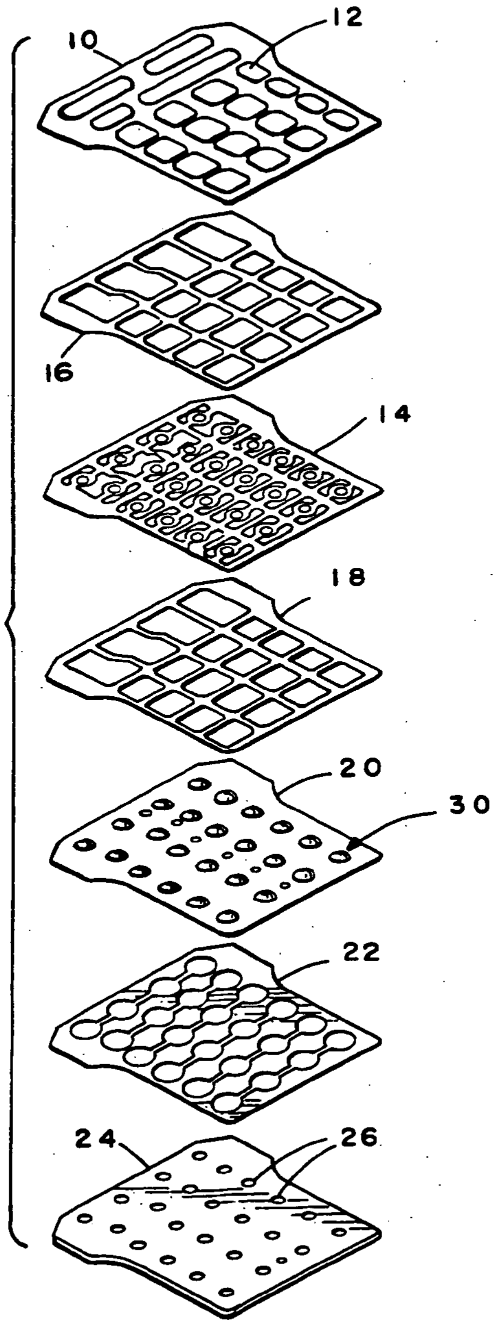
16. A keypad according to any one of claims 1-15, wherein said means for maintaining comprises a separate adhesive layer located between each of said layers of said keypad.

17. A keypad according to any of claims 12 through 16, wherein said planar layer includes means for stiffening a portion of said planar layer.

18. A keypad according to any of claims 1 through 17, wherein said means for stiffening includes a material printed on said planar layer between said planar layer and said tactile layer means.

19. A keypad according to claim 18, wherein said material printed on said planar layer between said planar layer and said tactile layer means comprises an at least translucent ring-shaped dielectric.

FIG. 1



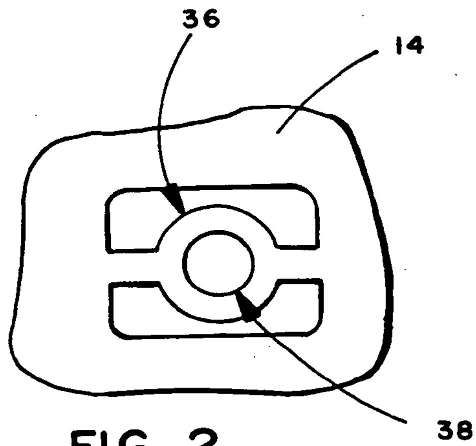


FIG. 2

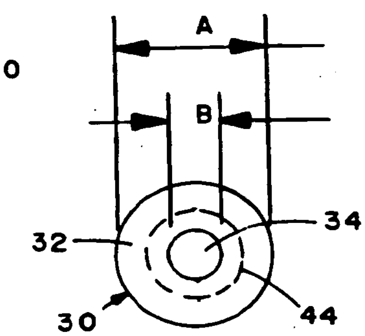


FIG. 3A

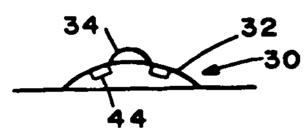


FIG. 3B

FIG. 4

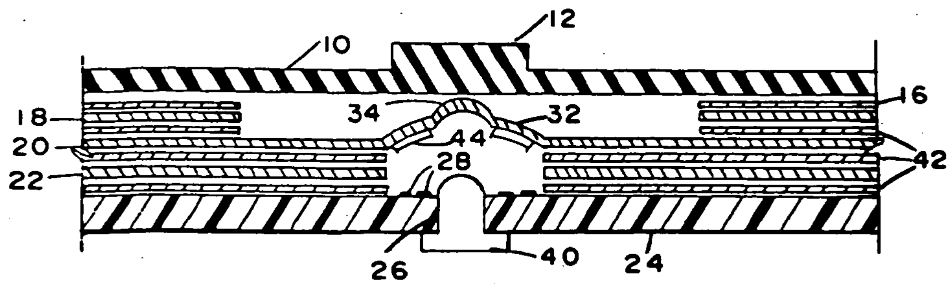


FIG. 5

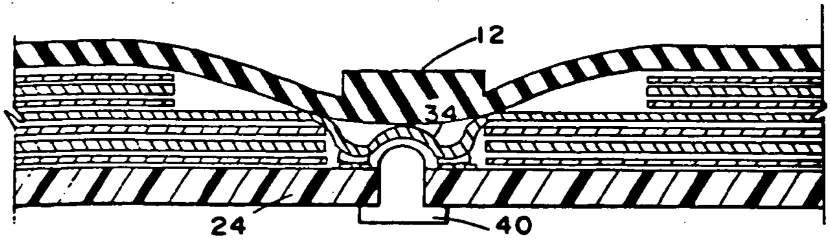


FIG. 6

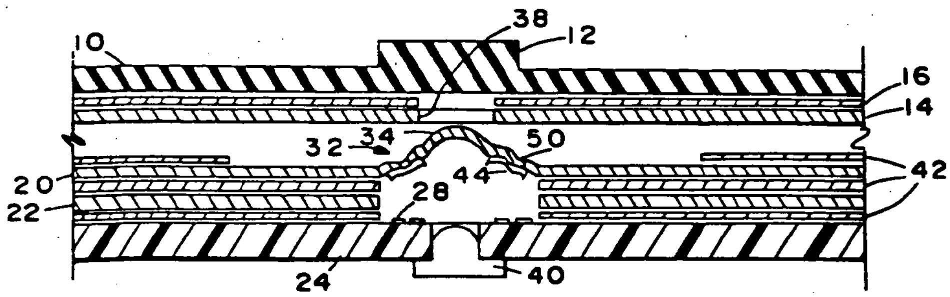


FIG. 7

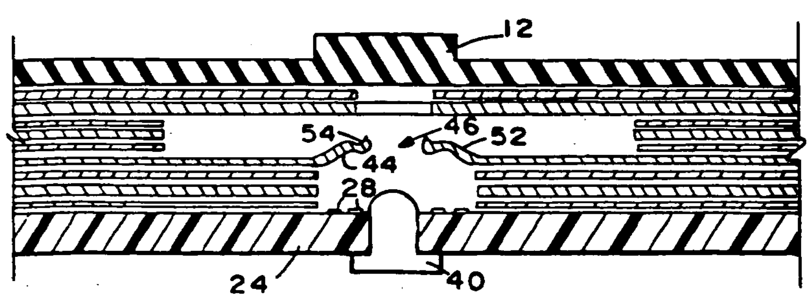


FIG. 8

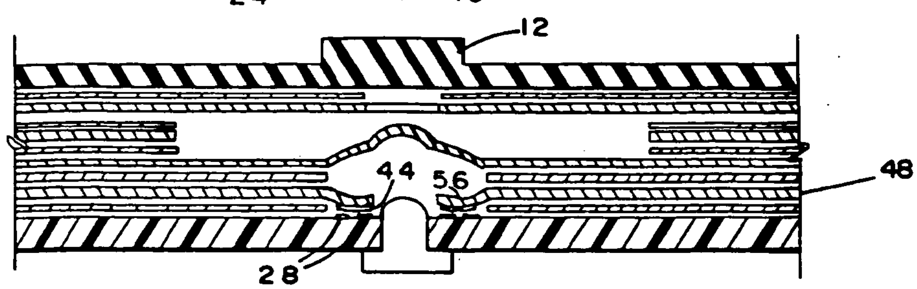
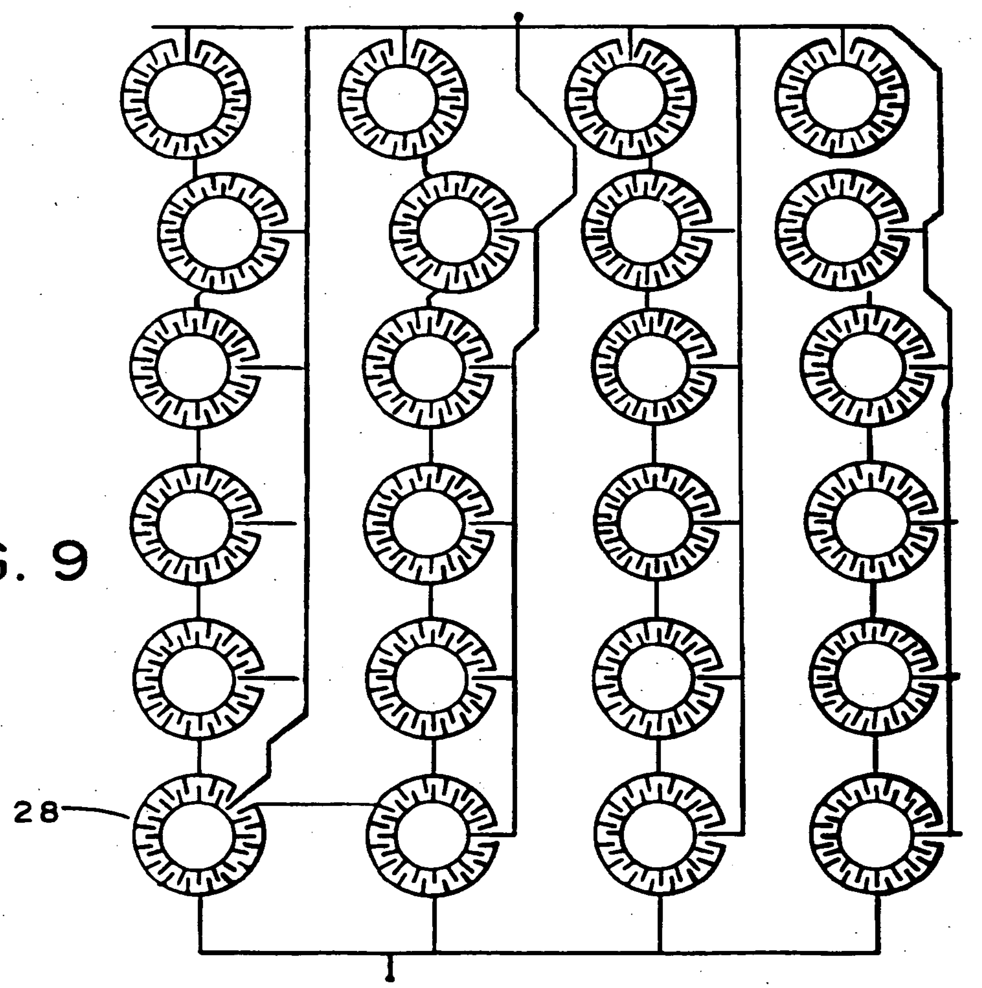


FIG. 9



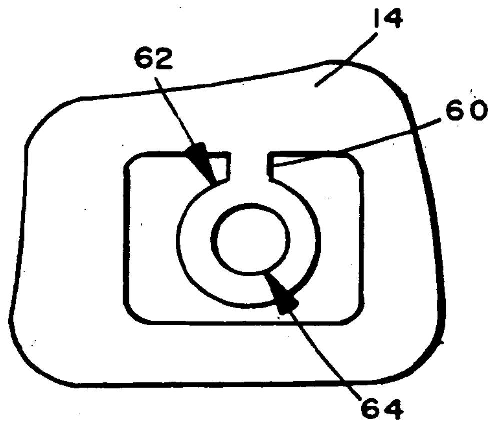


FIG. 10

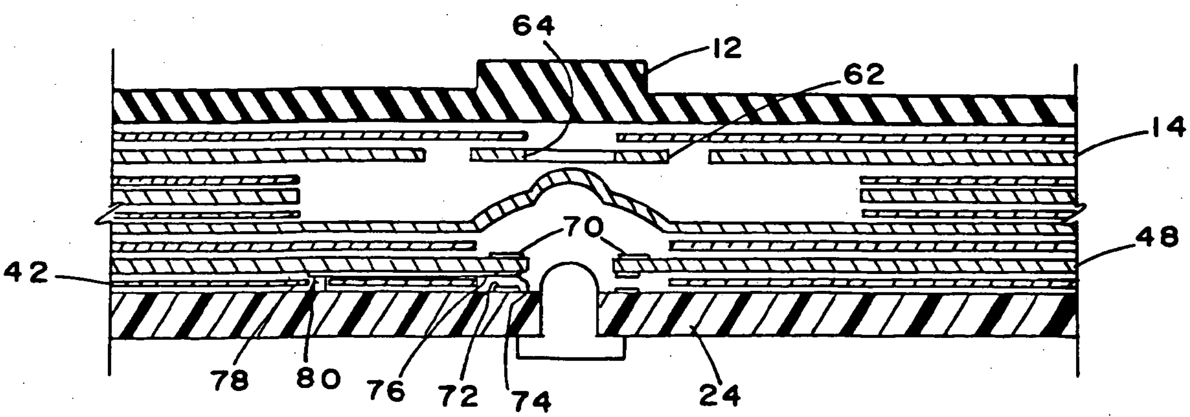


FIG. 11